ATTACHMENT A

SUBSTITUTE SPECIFICATION
(Including All Changes Made to the Specification in Published International Application No. PCT/SE2004/001019, Publication No. WO 2005/001361 A1)

IMPROVED HEAT CONDUCTOR SUPPORT DISC

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to the field of heating elements for industrial furnace applications, and in particular to an improved heat conductor support disc for use in a heating element.

DESCRIPTION OF THE RELATED ART

[0002] In industrial furnaces employed in the processing of materials and products at high temperatures, electrical heating elements are positioned and supported by ceramic discs. Typically, the heating resistor elements or heat conductors are inserted through apertures in the discs. In such discs, a center aperture for a supporting element is located on a symmetrical axis in the center of the disc. Apertures for heat conductors are provided uniformly distributed on at least one circle coaxial with a respective disc center. During service such discs tend to break due to thermal stresses induced in the disc.

[0003] The prior art can be exemplified by US-B1 5,543,603, which hereby is incorporated by reference. This US patent shows discs as described above.

[0004] An object of the present invention is to provide a ceramic heat conductor support disc for supporting electrical heating elements for heating furnaces, which discs have a much lower tendency to break due to thermal stresses.

SUMMARY OF THE INVENTION

[0005] The present invention relates to a ceramic heat conductor support disc for supporting an electrical heating element for electrically heated furnace installations. The support disc has a center aperture lying parallel to the longitudinal axis of the heating element, and one or more apertures located between said center aperture and the periphery of the disc. The disc is provided with one or more elongated openings running from said periphery to one of said apertures, where each elongated opening penetrates the whole thickness of said disc.

[0006] It is another object of the present invention to provide a heat conductor support disc which allows higher energy rates to the elements.

[0007] It is still another object of the present invention to provide an improved heat conductor support disc for use at higher temperatures.

[0008] It is yet another object of the present invention to provide a heat conductor support disc with improved properties at higher thermal cycling rates.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] The structure, operation, and advantages of the present invention will become further apparent upon consideration of the following description, taken in conjunction with the accompanying drawings in which:

[0010] Figures 1A and 1B show plan and cross-sectional views, respectively, of a first embodiment of a ceramic disc according to the present invention;

[0011] Figures 2A and 28 show plan and cross-sectional views, respectively, of a second embodiment of a ceramic disc according to the present invention;

[0012] Figures 3A and 38 show plan and cross-sectional views, respectively, of a third embodiment of a ceramic disc according to the present invention;

[0013] Figures 4A and 48 show plan and cross-sectional views, respectively, of a fourth embodiment of a ceramic disc according to the present invention; and

[0014] Figures 5A and 58 show plan and cross-sectional views, respectively, of a fourth embodiment of a ceramic disc according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0015] In Figure 1A a ceramic heat conductor support disc 1 for supporting an electrical heating element for electrically heated furnace installations is shown in a plan view. Said support disc 1 has a center aperture 2 lying parallel to the longitudinal axis of the disc. Further, the disc 1 is provided with one or more intermediate apertures 3 and 6 located between said center aperture 2 and the periphery 4 of the disc. The apertures can be circular or can be of another shape, such as an elliptical aperture such as aperture 15 shown in Figure 5A.

[0016] The periphery 4 can have a wave shape, as shown, or another shape such as circular.

[0017] According to the invention the disc 1 is further provided with one or more elongated openings 5 running from said periphery 4 through one of said apertures 6. The elongated opening penetrates the whole thickness of said disc 1.

[0018] An electrical heating element is supported by two or more discs 1 located in a row after each other, where the heating element runs through the said apertures.

[0019] The disc 1 is typically made of pure oxides or a mixture of oxides of the elements Al, Si, Mg, Zr, and/or Y, nitrides, respectively borides of the elements Si and/or Ti, or other suitable heat resistant ceramic materials.

[0020] A preferred embodiment can comprise 40 - 100 weight-% Al_2O_3 and 60 - 0 % SiO_2 plus some additives, such as for promoting the process when the disc is sintered.

[0021] The elongated opening and/or openings can be produced by pressing, sawing or extruding processes before or after firing.

[0022] Typically the heating element has a temperature that is higher than the temperature of the furnace when operated. When the furnace is turned off, the temperature of the heating element will decrease to about the furnace temperature. There are such applications where the furnace is cyclically turned on and off, i.e., exposed to extremely high cyclic thermal stress. There are also applications where the elements are operating continuously, where extremely high cyclic thermal stress occurs during, e.g., the changing of elements.

[0023] In accordance with the invention mechanical stresses that are induced thermally, when the disc is heated to its operating temperature, and those that are

induced when the temperature of the disc varies, will not reach the critical value for initiating a crack starting from the periphery of the disc and running inwardly.

[0024] The maximum value of such stresses is limited by means of the presence of the elongated opening 5, which results in that the thermally induced tensile stresses at the periphery will be limited.

[0025] According to a preferred embodiment of the invention, the length of said elongated opening 5 is limited to the maximum radius of the disc 1.

[0026] According to one embodiment, said elongated opening runs along a radius of said disc 1, as illustrated in Figures 1A and 3A by the openings 5 and 7.

[0027] According to an alternative embodiment, said elongated opening runs in another direction than along a radius of said disc 1, as illustrated in Figures 2A and 4A by the openings 8, 9.

[0028] According to another preferred embodiment, the width of the elongated opening 5, 7, 8, 9 is limited to the diameter of the aperture 6, 2, 10, and 11 in which it ends.

[0029] As is shown in Figures 2A and 4A, the elongated openings 8, 9 can well run through apertures 12, 13, 14

[0030] According to still another preferred embodiment, the elongated opening has the same width, or a width that varies, over the length of the elongated opening.

[0031] According to yet another preferred embodiment, said elongated opening ends in the center aperture 2, as illustrated in Figures 1A and 2A.

[0032] According to yet another embodiment of the invention, there are two or more of said elongated openings 16, 17 in the disc 1 as illustrated in Figure 5A.

[0033] In Figure 5A it is shown that the holes 3 can be asymmetrically located, as well as that the two elongated openings 16, 17 can be directed in different directions. The apertures 3 can be concentrated to one side of the disc, thereby concentrating the radiation in that direction.

[0034] Since there is one or more elongated openings in said disc, values relating to the maximum mechanical stress for a disc 1 of the present invention are in a range of no more than 50 - 70% of the stress in a disc of the state of the art.

[0035] In addition the mechanical strength has different values in different directions, which is of importance for the positioning of the disk in the heating application. It is therefore advantageous to place the different discs, located one after the other along the length of the heating element, such that the discs are rotated so that the elongated openings of the respective discs point in different radial directions.

[0036] Although particular embodiments of the present invention have been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications can be made without departing from the spirit of the present invention. It is therefore intended to encompass within the appended claims all such changes and modifications that fall within the scope of the present invention.